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RECENT COLONIZATION OF THE SAN FRANCISCO BAY AREA, CALIFORNIA, BY EXOTIC MOTHS (LEPIDOPTERA: TINEOIDEA, GELECHIOIDEA, TORTRICOIDEA, PYRALOIDEA)

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Abstract.—Records are given documenting the establishment of seven species of moths in the San Francisco Bay area, California, during 1955–1988: *Opogona omoscopa* (Meyrick) (Tineidae), *Oegoconia quadripuncta* (Haworth) (Blastobasidae), *Mirificarma eburnella* (Denis & Schiffermüller) (Gelechiidae), *Crocidosema plebiana* Zeller (Tortricidae), and three pyraloids, *Uresiphita reversalis* (Guenée), *Parapediasia teterrella* (Zincken), and *Achroia grisella* (Fabr.). Ten additional Microlepidoptera that have colonized this region in the past 50 years are tabulated with literature sources. Most of these species spread to the San Francisco area after establishment in southern California, often following long periods (17–60 years) of naturalization there.

Key Words.—Insecta, Lepidoptera, Tineoidea, Gelechioidea, Tortricoidea, Pyraloidea, colonization

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Insects make up an important part of the alien fauna that has been transported by humans to colonize different parts of the world. By 1982, 1700 such immigrants had become established in the 48 contiguous U.S. states, including 134 Lepidoptera (Sailer 1983). Although Sailer calculated that Lepidoptera are poorly represented, relative to their species numbers, as contrasted to Coleoptera, Hymenoptera and particularly Homoptera, some Microlepidoptera and Pyraloidea have become frequent travelers via their association with human activities.

California is an adopted home to more than 60 species of these smaller moths, including many of our most notorious insects, in households (clothes moths, stored foods moths), gardens (e.g., azalea leafminer, buddleia budworm, cotoneaster webworm), and agricultural situations (codling moth, Oriental fruit moth, pink bollworm, etc.). Other species are detritivores, scavengers, or fungus feeders and seldom attract attention. For example, *Opogona omoscopa* (Meyrick), *Nemapogon granellus* (L.), *Oinophila v-flavum* (Haworth), *Batia lunaris* (Haworth), *Endrosis sarcitrella* (L.), and *Oegoconia quadripuncta* (Haworth) are all common members of the urban insect community in California but are seldom noticed except by lepidopterists. A few adventive colonists are even encouraged for possible weed suppression, such as *Agonopteryx alstroemeriana* (Clerck), a specialist on poison hemlock, and *A. nervosa* (Haworth) and *Uresiphita reversalis* (Guenée), which feed on genista and other brooms, although the last species sometimes eats other ornamental legumes or native lupines and causes mixed emotions, varying with circumstances.

Many of these lepidopterous colonists became established in California so early in the immigration of European and Oriental humans that a history of their introduction and spread cannot be reconstructed. There is essentially no record

of the Microlepidoptera fauna of the Pacific coast of North America prior to the remarkable expedition in 1871–1872 in northern California and Oregon by Lord Walsingham, during which he collected and later described many of our native species (see Essig 1941, Powell 1964a: 5). More extensive collections in urban and agricultural situations were made by Koebele and Coquillett during the 1880s and 1890s, primarily in Alameda and Los Angeles counties. Otherwise, there are few records of Microlepidoptera in California prior to the turn of the century, and any other record that may have existed of the fauna in the San Francisco Bay area during the 19th century was lost in the 1906 fire that destroyed the collections of the California Academy of Sciences.

Despite federal and state efforts at quarantine against imported insects, as the human population has increased and ease of transportation improved, the parade of incoming insects has continued. California's population increased an appalling 25%, and that of the S. F. Bay area 16%, during the 1980s alone. Hence, it is not surprising that at least 17 species of small moths have taken up residence in this area during the past half century (Table 1). Included are six species that appear to have colonized during the 1980s. The occurrence of two of these is documented elsewhere: *Athrips rancidella* (Powell 1985) (Fig. 4) and *Agonopteryx alstroemeriana* (Powell & Passoa in press). Here, I give data for the remaining five, and for three species that have been established for longer periods, but apparently not documented in detail in the literature.

Methods.—I recovered data from specimens in the major California collections through 1990, by searching the unidentified accessions and confirming identifications in the determined material. Voucher specimens in collections are indicated in the text by the following abbreviations:

CAS, California Academy of Sciences, San Francisco; CDFA, California Department of Food & Agriculture, Sacramento; EME, Essig Museum of Entomology, University of California, Berkeley; FAC, Fresno County Agricultural Commissioner's Office, Fresno; LACM, Los Angeles County Museum of Natural History; SDNH, San Diego Natural History Museum; SJAC, San Joaquin County Agricultural Commissioner's Office, Stockton; SJS, San Jose State University, Department of Entomology; UCD, University of California, Davis, Bohart Entomological Museum; USNM, U.S. National Museum of Natural History, Washington, D.C. In addition, card- and computer-file records at CDFA were made available. Most of these are not represented by voucher specimens. Data from the identified material in the USNM were recorded, but not from unidentified accessions, through 1977 (*Opogona, Oegoconia, Achroia*) and 1988 (*Crocidosema*).

I made blacklight trap collections in suburban sites at Walnut Creek, Contra Costa Co., from 1961 to 1973 (EME). In the first six years, samples were made most nights I was in residence, near the foot of Shell Ridge, while those during August, 1966, to 1973 were sporadic, at a site near San Ramon Creek. The two localities are respectively about 2.75 airline km NW and 2.5 km SW of the Highway 24-680 interchange. I recorded moths in urban Berkeley on nearly all dates I was residence from May 1978 through 1990. During 1978–June, 1984, I sampled at a site 3.0 airline km NNW of the University of California west gate and during July 1984 through 1990, at a second locality 0.33 airline km north of the 1978–1984 site. This area has been residential since 1915–1920.

Table 1. Exotic Microlepidoptera and Pyraloidea that became established in the San Francisco Bay area during 1939–1988. (l = local colonization; w = widespread occurrence in S. F. Bay area; u = uncertain status.)

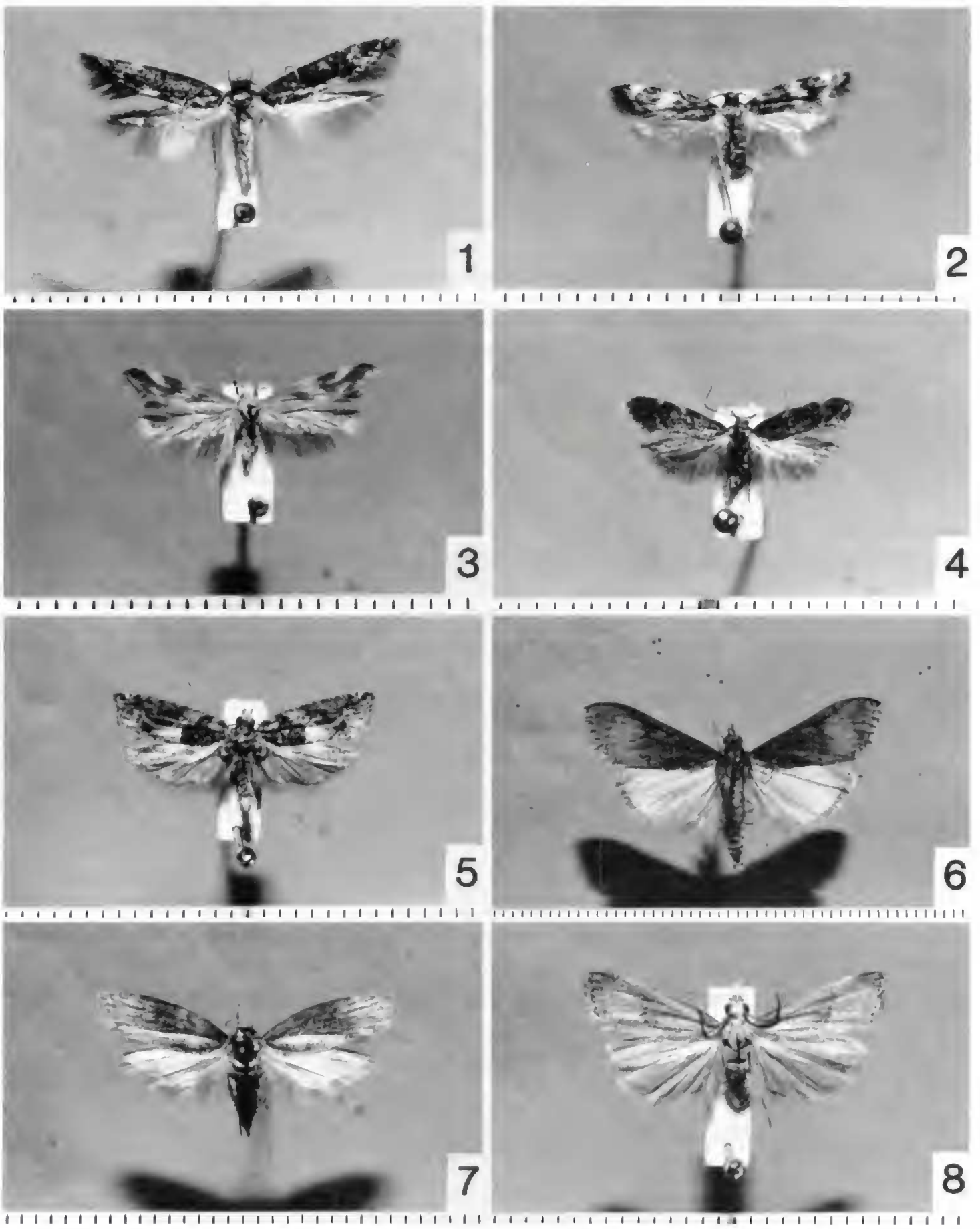
Taxa	Earliest record	Present status	Source
Tineidae:			
Oiophila v-flavum (Haworth)	1947, Stanford	w	Tilden 1951, Powell 1964b
Opogona omoscopa (Meyrick)	1972, Berkeley	w	CDFA, Davis 1978
Oecophoridae:			
Agonopteryx alstroemeriana (Clerck)	1983, Berkeley	w	Powell & Passoa, in press
Batia lunaris (Haworth)	1956, Marin	w	Powell 1964c
Esperia sulphurella (Fabr.)	1966, El Cerrito	l	Powell 1968
Pyramidobela angelarum Keifer	1942, San Jose, San Mateo	w	Keifer 1942
Blastobasidae:			
Oegoconia quadripuncta (Haworth)	1959, Redwood City, 1976, Berkeley	w	present data
Symmoca signatella (Herrich-Schaeffer)	1959, Redwood City	w	Powell 1960
Gelechiidae:			
Athrips rancidella (Herrich-Schaeffer)	1983, Berkeley	l	Powell 1985
Mirificarma eburnella (Denis & Schiffermüller)	1985, Morgan Hill	u	present data
Tortricidae:			
Crocidosema plebiana Zeller	1988, Berkeley	l	present data
Spilonota ocellana (Denis & Schiffermüller)	1939, San Jose	w	Keifer 1939
Cnephasia longana (Haworth)	1947, San Mateo	w	Keifer 1948, Powell 1964a
Platynota stultana (Walsingham)	1967, Antioch, Albany	w	Powell 1983
Pyralidae:			
Uresiphita reversalis (Guenée)	(1966, Stevens Cr.), 1980, San Jose	w	present data
Parapediasia teterrella (Zincken)	1988, Berkeley	l	present data
Achroia grisella (Fabr.)	1955, San Jose	w	present data

Tineidae

Opogona omoscopa (Meyrick)

(Fig. 1)

Opogona omoscopa was originally described from Australia in 1893 and since has been found widely distributed in pan-global warm regions, probably in large part the result of man's activities. The larvae feed in decaying, often damp plant



Figures 1–8. Figure 1. *Opogona omoscopa*; Berkeley, October 1978. Figure 2. *Oegoconia quadripuncta*; Berkeley, June 1988. Figure 3. *Mirificarma eburnella*; Nevada Co., May 1980. Figure 4. *Athrips rancidella*; Berkeley, May 1983. Figure 5. *Crocidosema plebiana* Zeller; Berkeley, November 1990. Figure 6. *Uresiphita reversalis*; Berkeley, December 1983. Figure 7. *Achroia grisella*; Berkeley, August 1983. Figure 8. *Parapediasia teterrella*; Berkeley, May 1989.

material, including wood, bark and dead leaves (Davis 1978) and evidently are easily transported with roots and other plant material. This species has been known in Hawaii since 1905, where it is widespread and abundant (Zimmerman 1978), a likely source for introduction into California.

The earliest Pacific coast record is at Goleta, Santa Barbara Co., California, in May, 1969 (CDFA and Davis 1978), which probably was soon after establishment, because the adults come to lights readily, and I collected at Goleta for five weeks during June and July, 1965, without finding *O. omoscopa.* The moths were taken at nearby Santa Barbara and Summerland in June and July, 1969 (USNM). In fall, 1970, C. Nagano collected a series at Santa Monica, Los Angeles Co. (LACM), and by summer, 1971, *O. omoscopa* was widespread in southern California, having been detected in Gardena (LACM), Los Angeles (USNM) and Rancho Santa Fe, San Diego Co. (EME).

The first records in the S. F. Bay area were two larval collections on ginger roots in a market in Berkeley, in May, 1972, and May, 1973 (CDFA). Ginger roots sold in this area are normally imported from Hawaii. Hence, it is possible that a separate introduction from overseas, rather than from southern California, initiated the S. F. Bay area population. There also were larval collections from Corte Madera, Marin Co. in January, 1974, and Fremont and Livermore, Alameda Co. in 1976 (CDFA), but we do not have documented records of colonies outside of buildings until adults began appearing at lights in the 'east bay' in 1978 (EME). The species has been common in Berkeley since that time, having been recorded on 15–30 dates each year. The moths are seen in every month but are most prevalent in September–November (50% of all records during 1985–1990: JAP, unpublished data).

The peculiar, widely divergent labial palpi, flattened, smooth front and elongate, plicate maxillary palpi make *O. omoscopa* easily recognizable among all California Lepidoptera.

Blastobasidae

Oegoconia quadripuncta (Haworth)

(Fig. 2)

This Palaearctic species is distinctive in the urban fauna of California, having black forewings spotted with yellow. In Europe the larvae are reported to feed on decaying vegetable matter, and we reared *O. quadripuncta* from leaf litter beneath *Quercus* by P. Rude (EME). In England there is a single annual generation, with adults active in July and August, occurring in habitats such as hedge-bottoms (Emmet 1979).

Oegoconia quadripuncta was introduced into the Atlantic states long ago; it was redescribed as *novimundi* Busck, a synonym, in 1915, and it was established in Pennsylvania and New jersey by 1920 (USNM). The adventive range had reached Washington, D.C. by 1927, Martha's Vineyard, Massachusetts by 1941 and Illinois by 1956 (USNM).

There does not seem to be a published report of this species' occurrence in California, such as during Keifer's summaries of introductions during 1935–1955 (Powell 1991). However, *O. quadripuncta* evidently was introduced into southern California, presumably from the eastern U.S., more than 50 years ago. There are specimens from South Pasadena, L. A. Co., collected in August, 1938, and June, 1940 by C. Henne (USNM), and the range extended to Ventura Co. (Ojai) by 1961 (EME) and Orange Co. by 1962 (CDFA). The species had become common in Los Angeles by the time Donahue began sampling there in the early 1970s (LACM).

The first record I have seen in the S. F. Bay area is August, 1959, at Redwood City, San Mateo Co. (EME), but *O. quadripuncta* was not known east of the bay until adults appeared at lights in Berkeley in 1976. The species seems to be becoming more prevalent at Berkeley; it was observed on two or three dates per season until 1986, then five dates in 1987 and 1988, six in 1989, and nine in 1990 (despite 44 nights absence from sampling during summer), when the flight period extended from early June to mid September.

Oegoconia evidently colonized the Central Valley about a decade later than the S. F. Bay area. I did not find the species in Davis when I sampled there in 1956, but there are more than a dozen collections records from Sacramento (1967–1968), Davis (1969–1971) and Fresno (1970–1971) (CDFA, UCD).

Gelechiidae

Mirificarma eburnella (Denis & Schiffermüller) (Fig. 3)

This moth was reported in North America under the names *M. formosella* (Hübner) (Anonymous 1969, Dowell & Gill 1989) and *M. flamella* (Hübner) (Hodges 1983), which are considered to be synonyms of *M. eburnella* (Pitkin 1984). The species is widespread in Europe and the Mediterranean region, where it feeds on *Medicago,* including alfalfa, and other legumes (Pitkin 1984).

This gelechiid is distinctive in the California fauna, having rust-orange and yellow patterned forewings. It was first recognized in North America when larvae were found defoliating Ladino clover, *Trifolium repens* L., in the Sacramento Valley in Sutter, Placer and Sacramento counties, in April, 1969. Identifications at the time revealed that I had collected specimens near Georgetown, El Dorado Co., in June, 1967 (Anonymous 1969; CDFA, unpublished report). The species was already widely established, however, as evidenced by specimens determined later that had been taken by A. Keuter and G. Keuter in May, 1965, and May–June, 1967, at Citrus Heights, Sacramento Co. (CAS). There are also two specimens labelled 12 Oct 1967, in the Keuter material, suggesting a bivoltine life cycle.

Berkeley students and I found *M. eburnella* at additional localities in El Dorado Co. (Greenville, Somerset) during May and June, 1967 and 1978, and at several sites around the Sierra Foothill Field Station (near Smartville), Yuba Co. and Rough and Ready, Nevada Co., in May, 1980. The species appeared at La Grange, Stanislaus Co. in 1971 (CDFA), at a site that has been sampled for many years by R. P. Allen. The 1971–1980 localities are 55 km NW to 134 km SE of a line between Citrus Heights and Georgetown, along the foothills of the Sierra Nevada.

During a census of Lepidoptera of serpentine grasslands in Santa Clara Co., D. D. Murphy and I collected two specimens of *M. eburnella* at Kirby Canyon Ridge (approx. 6 airline km NE of Morgan Hill), on 29 Apr 1985. This suggested that populations of this gelechiid had spread across the Central Valley and inner Coast Range into the Santa Clara Valley. However, more intensive survey on numerous dates at this locality and serpentine grasslands at a dozen other sites in Santa Clara, San Mateo and Marin counties during March through May, 1986–1987 and 1990 failed to recover *M. eburnella.* Possibly the four year drought following 1985 suppressed the clover or other hostplants severely, limiting or eradicating

the immigrant moth population from this habitat. Hence, the residency status of *M. eburnella* in the S. F. Bay area is uncertain.

Tortricidae
Crocidosema plebiana Zeller
(Fig. 5)

This species was originally described from Sicily in 1847, but its native distribution is unknown. It occurs pan-globally in warmer regions, probably having been transported by man since early times. *Crocidosema plebiana* was reported from Hawaii by several early authors, but Zimmerman (1978) regards the Hawaiian *Crocidosema* as three distinct, endemic species. Differentiation of Pacific island populations also is discussed by Clarke (1971, 1986). The evidence suggests that *C. plebiana* (sens. lat.) occupied a broad range, and that North American populations probably originated from the Mediterranean. The larvae of *C. plebiana* feed in flowers and fruit of various Malvaceae, including *Hibiscus,* and have been taken on cotton several times in California.

Heinrich (1923) reported *C. plebiana* in the U.S. from California and Texas. In addition, the species has been collected widely in the south, in Louisiana (1916), Florida (1918 onwards) and South Carolina (1944) (USNM; Kimball 1965). The species has long been established and abundant in southern California; the earliest available record is June, 1911 at San Diego, collected by W. S. Wright (USNM). In 1917–1918, it was collected at Chula Vista, San Diego Co. (CAS). By about 1920 it occurred in the San Bernardino area (Barnes collection: USNM), at Riverside by 1932, and on Santa Catalina Island by 1931 (CDFA, LACM). By that time probably it was established throughout much of the Los Angeles basin and Orange Co., where its colonization was documented in the 1940s during the statewide Oriental fruit moth survey by dimalt bait traps (CDFA). Specimens were reared from *Hibiscus* buds at Exposition Park, Los Angeles in 1942 (LACM). The distribution also extended to the coast in the Ventura (1943) and Santa Barbara (1936) areas (CDFA, LACM), and San Luis Obispo Co. (Pismo Beach) by 1959 (EME). *Crocidosema plebiana* was found in the San Joaquin Valley in Kern Co. in 1968 (CDFA).

I had not seen any subsequent records north of a line between Pismo and Bakersfield until *C. plebiana* appeared in Berkeley recently. In late September and October, 1988, two males came to a blacklight, but none was observed in 1989, suggesting that the moths captured in 1988 did not represent an established population. In 1990, however, *C. plebiana* reappeared, with males attracted to blacklight on 9, 12 Jul and on 10 dates between 11 Sep and 17 Oct, confirming the colonization.

Pyralidae
Uresiphita reversalis (Guenée)
(Fig. 6)

This large pyraustine, which is known as "the genista caterpillar," has bright rust-brown forewings and ochreous-yellow hindwings. The moths are primarily nocturnal and come to lights but are easily flushed into activity during the daytime. The larvae are aposematic in color and behavior; they are orange and black spotted, live exposed, without a shelter, and are rendered distasteful by sequestered

alkaloids (Bernays & Montllor 1989). They often occur in defoliating numbers. Hence, populations are easily seen in the field, and this species is not likely to colonize unnoticed for long.

Although its relatives are Old World species, *Uresiphita reversalis* is believed to be a native Nearctic species, having been described originally in 1854 from "North America" without a specified locality. The natural distribution is unknown, but it may have encompassed parts of the southeastern U.S. and Mexico. The present range is reported to be "southern Canada to southern Florida and west to California" (Munroe 1976), but it is likely sustained in northern areas by migrations, not continuously resident populations. In California, moreover, populations are dependent upon introduced plants, particularly *Genista,* grown as ornamentals or in weedy situations, and there are no known records prior to 1930, so *U. reversalis* is assumed to be an introduced or adventive exotic.

In the west there are records as early as 1912 in the Davis Mountains, Texas (LACM) and 1927 in the mountains of southern Arizona (CAS), and there are scattered collections from the Mexican plateau and coastal Sinaloa (EME, UCD), suggesting that native populations may have lived in these areas.

The earliest known record in California is a series collected in Los Angeles in September, 1930, by J. A. Comstock (LACM). By late 1931, *U. reversalis* occurred widely in urban Los Angeles, Orange, San Diego and Ventura counties and had been reared from "Genista and other brooms" at several localities (Keifer 1931). There are records at Riverside and San Bernardino by September, 1932, and Santa Barbara in 1933 (CDFA, CAS, LACM). McKenzie (1933), who described the early stages and recorded hostplants, stated that the initial appearance of this insect in California had been noted only recently.

Populations seemed to stabilize in cismontane southern California during the following 30 years, and there are collection records for nearly every year, indicating that residency was continuous.

The earliest known collection of *U. reversalis* in the San Francisco Bay area is August, 1966, at Stevens Creek [5 km SW of Cupertino], Santa Clara Co., by R. Denno (UCD). This record is puzzling because one would expect this species to have appeared first in an urban area, rather than a forested canyon in the foothills, and because if the collection sampled an established population, it is surprising that no other colonies were detected in the south bay area during the subsequent 13 years. Continuous residency is documented beginning in 1980. Larvae were collected from *Laburnum* in Fremont in July, 1980 (CDFA) and on *Genista* at San Jose at least three times between September, 1980, and September, 1981 (CDFA, EME, SJS), the first by F. Iltis (W. E. Ferguson, personal communication); and the species rapidly colonized northward in the S. F. Bay area during the next 10 years. In 1983, larvae of *U. reversalis* were found in Oakland by P. Neyland (EME), and adults began appearing at localities that R. L. Langston, W. W. Middlekauff or I had been sampling regularly: Antioch, Contra Costa Co. (August), Berkeley (November), San Bruno Mts., San Mateo Co. (December), in Contra Costa Co. at El Cerrito the following year, and Fish Ranch Canyon and Kensington by 1985 (CAS, EME).

Uresiphita reversalis was widely established north of San Francisco Bay by the late 1980s, in Marin (1986) (including Angel Island and Marin Island, 1989), Napa (1988) and Solano (1987) counties (CDFA, EME).

It is likely that *U. reversalis* also spread through the Central Valley and Sierra Nevada foothills during or preceding the 1980s. By 1968, when records were suspended in a card file system at CDFA[1], there were no listings of this pyralid from counties north of the Transverse Ranges; also, there are no voucher specimens for records during the following 11 years. Larvae were collected at Tracy, San Joaquin Co. in late 1982 (SJAC), and at Bakersfield, Kern Co. and near Fresno, Fresno Co. a year later (CDFA, FAC). By 1987, when computerization came on line at CDFA, *U. reversalis* was found in Kern, Tulare, Merced, Placer, and Sacramento counties; by 1988 in Yolo Co. (January) and in the northern Sacramento Valley, in Sutter and Butte (October), and Shasta (1989) counties (CDFA) (Fig. 9). Simultaneously, *Uresiphita* colonized the foothills of the Sierra Nevada in Amador, Nevada, and Tuolumne counties, to elevations of 550–800 m at Sonora and Grass Valley (CDFA).

The genista caterpillar feeds on a variety of legumes, particularly those of the tribe Genisteae (Fabaceae) including *Genista, Cytisus,* and *Lupinus,* as well as on *Baptisia* and *Sophora* (Dyar 1901, McKenzie 1933, Kimball 1965, Munroe 1976, Bernays & Montllor 1989). In California, the adventive populations evidently are dependent primarily on *Genista* (= *Cytisus*) *monspessulana* (L.) (French broom) and horticultural hybrids. *Cytisus scoparius* (L.) (Scotch broom) has been recorded as the larval host on several occasions, but at least some of these evidently originate from plant misidentifications or equating the common names "genista," "broom" and "Scotch broom" as applied to various *Genista* species. For example, there are records from "Scotch broom" in San Diego County in 1931 (CDFA) and 1967 (EME), but *Cytisus scoparius* was not established anyplace south of Monterey County by 1978 (Mountjoy 1979).

There are numerous records of larvae having been collected on nonleguminous plants, including *Buddleia* (Loganiaceae) (McKenzie 1933; CDFA [1964]), asparagus fern (Liliaceae), *Taxus* (Taxaceae), *Gardenia* (Rubiaceae) (CDFA), and "chamise" (SDNH). Such records, along with other evidence ("pupating in doorway," "barbeque cover," etc. [CDFA]), probably reflect a propensity of late instar larvae to wander. Particularly when colony densities are high and *Genista* is defoliated, larvae of *U. reversalis* are liable to be found on various other plants in the vicinity.

In the S. F. Bay area, larvae of *U. reversalis* feed on native *Lupinus,* including *L. chamissonis* Eschscholtz when growing in proximity to *Genista monspessulana* (Pt. Molate, JAP 87G4, EME), and on *L. arboreus* Sims according to Bernays & Montllor (1989). In no-choice feeding tests in the laboratory, Bernays and Montllor found that larvae did not feed and soon died when offered certain legumes, including *Medicago, Trifolium, Vicia,* and *Pickeringia.* They fed successfully on

[1] *Uresiphita reversalis* is rated "C" in pest status by CDFA (a native or established species, against which no agricultural quarantine action may be needed). Most "C" and "D" (beneficial or non-phytophagous non-economic) rated insects ceased to be routinely entered in the CDFA card system in 1968, due to system size restrictions; those rated "Q" [old "X"] (unassessed exotic), "A" (quarantine action mandated) or "B" (county level quarantine), however, continued to be automatically entered in the post-1968 card database. Individual instances of "C" or "D" rated insects also could have been entered, if requested by a CDFA taxonomic specialist for the group; their post-1968 absence on cards does not necessarily mean that no CDFA identification was done. In 1987, the CDFA data system was computerized, and all data from CDFA identifications was once again routinely entered.—(Ed.)

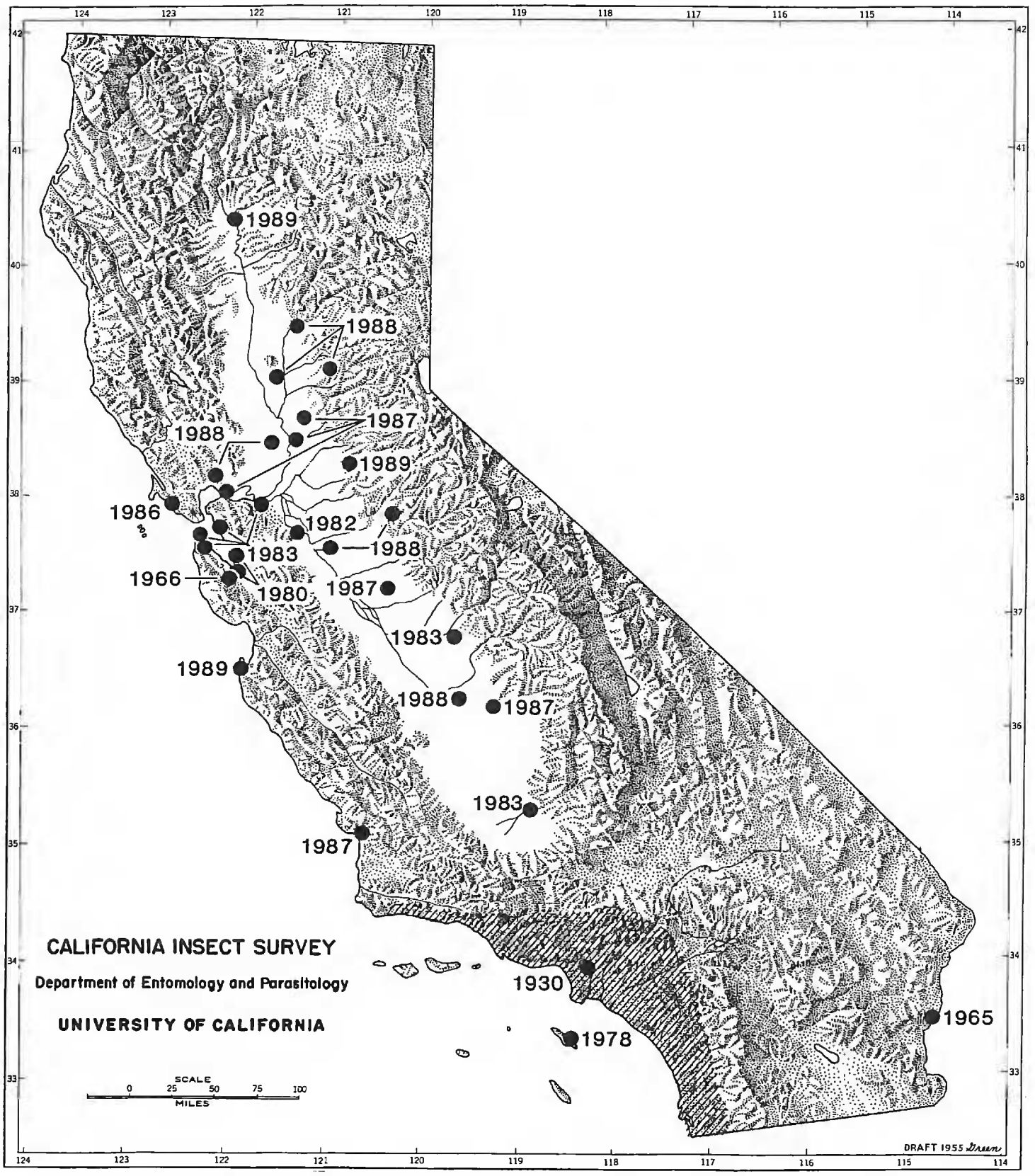


Figure 9. Geographical distribution of *Uresiphita reversalis* in California: by 1931 (shaded area); later dated localities refer to first records in peripheral areas of southern California and first records in counties north of the Transverse Ranges.

Lupinus arboreus, Cytisus striatus (Hill), *G. monspessulana,* and *Cytisus scoparius,* and late instar larvae significantly preferred *Lupinus* over *G. monspessulana,* when given the choice.

Bernays & Montllor (1989) believed that the data indicate that the main hosts of *U. reversalis* in California are species of *Lupinus.* However, I have not seen any evidence that populations inhabit less disturbed plant communities where they would be sustained solely by native plants. Moreover, there are no specimen voucher records of larvae on native plants outside of urban situations after more than half a century residency in southern California and none in more northern areas (CAS, CDFA, EME, LACM, SDNH, SJS, UCD). The CDFA has records

of larval collections from "*Lupinus* sp." from Castro Valley, Alameda Co. (1988), Redding, Shasta Co. (1989) and Santa Maria, Santa Barbara Co. (1988) in garden, park, and nursery settings. Some exotic ornamental legumes also serve as hosts, including *Laburnum* at El Cerrito (JAP 84K1) (EME) and *Piptanthus* at the Strybing Arboretum, San Francisco (CAS).

Parapediasia teterrella (Zincken)
(Fig. 7)

Described in 1821 from Georgia, this was one of the first pyralids known in North America. It is widespread in the eastern U.S. and is often extremely abundant at lights in urban areas, such as around Washington, D.C. The original geographical distribution no doubt was modified by human colonization of North America; by the late 1800s it encompassed the Atlantic and midwestern states. Murtfeldt (1893) reported that *P. teterrella* had become more abundant during the past two or three years around Kirkwood, Missouri, than all other crambids combined.

There are records in the southwest as early as half century ago: Tulsa, Oklahoma (1940); Albuquerque, New Mexico (1944); Tucson (1935) and Madera Canyon (1947), Arizona (LACM). Hence, *P. teterrella* may have spread into that region with urbanization during the early 1900s.

The earliest known occurrence in California is August, 1954, at South Gate, Los Angeles Co. (LACM). Records from other parts of southern California and the Central Valley indicate that this lawn moth had colonized in the early 1950s, then spread southward and northward within a few years (Fig. 10). I collected the urban lawn moths, *Crambus sperryellus* Klots and *Tehama bonifatella* (Hulst) and did not find *Parapediasia teterrella* in San Diego during 1953–1956; but in 1957–1959, light trapping by A. A. Lee and R. A. Mackie produced *P. teterrella* at widely separated inland localities: Escondido and Otay, San Diego Co. and at several coastal sites in 1958–1959 (SDNM, EME). The colonization reached Bakersfield, Kern Co., by July, 1959, then quickly spread through the Central Valley, recorded at Madera (1960), Sacramento (1967), and Davis, Yolo Co. (1969) (CDFA). I did not find *P. teterrella* in urban Davis when I sampled there during the summer of 1956.

The adventive populations appear to have extended through the delta region to S. F. Bay, having been recorded at the Antioch National Wildlife Refuge in August, 1981, and at Berkeley beginning in 1988 (EME), when two adults came to blacklight in October. The following season I recorded *P. teterrella* on 16 dates between 19 May and 17 Oct; in 1990 the species became more abundant and seasonally extensive, flying from 9 Apr to 24 Oct (34 dates recorded), often with 5–10 individuals observed. At Berkeley this species has become the most prevalent lawn moth, while *Tehama bonifatella* (Hulst) appears to have declined in numbers (eight and 13 dates in 1989 and 1990, down from 19–29 dates in 1985–1988), although its adult activity was more prolonged than that of *P. teterrella* in 1990 (25 Mar to 12 Nov). The data suggest that competitive displacement is occurring at this site.

Parapediasia teterrella may be better adapted to inland than coastal areas in California, as I have not seen records of its occurrence in urban areas of the coastal counties, from Ventura to San Francisco.

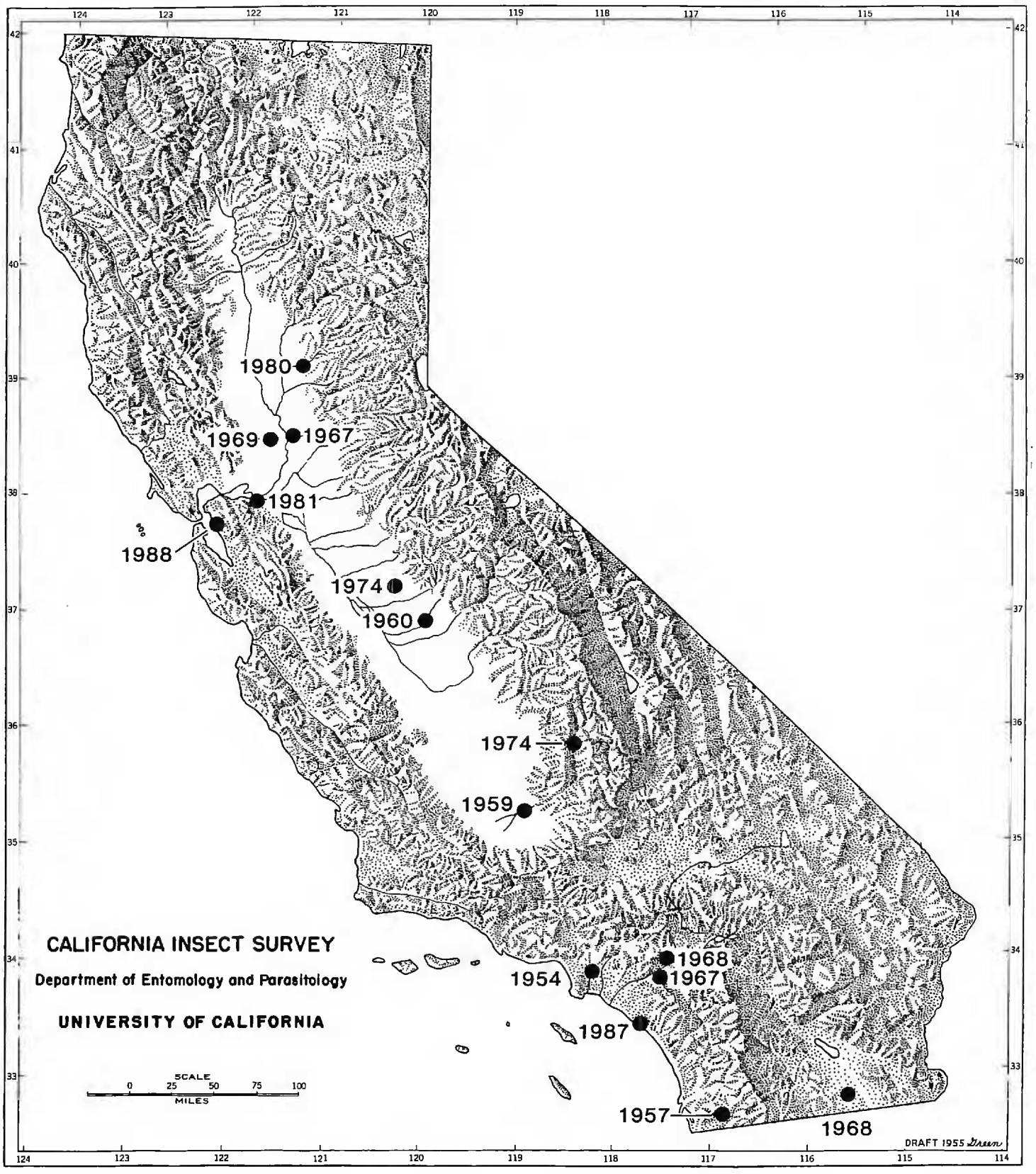


Figure 10. Geographical distribution of *Parapediasia teterrella* in California: dated localities refer to first record in each country.

Achroia grisella (Fabr.)
(Fig. 8)

The lesser wax moth is described in the stored products and general entomological literature as a cosmopolitan insect, but evidently it has not been formally reported in California. *Achroia grisella* is not mentioned by Essig (1926), nor by Keifer during 1927–1954 (Powell 1991); and there were no records from the Pacific states in the USNM in 1977. Larvae of this moth, which is uniformly mouse gray with a contrasting pale yellow head, typically live in old honeycombs but also are said to feed on dried fruit and "apparently" on dried insects (Forbes 1923). The species was originally described from Europe but has been widely established in the Atlantic states at least since the 1890s (USNM).

There are records of *Achroia grisella* in southern California dating back to the early 1900s, but apparently the adults are not readily attracted to lights, and populations likely have been more prevalent and widespread than records indicate. A series was collected by W. S. Wright in San Diego on at least six dates between 1908 and 1915 (SDNH); there are two specimens from the E. Piazza collection, probably from San Diego, taken in 1921, and *A. grisella* was taken at Del Mar, San Diego Co. in 1934–1942 (CDFA, LACM).

Circumstantial evidence suggests that the lesser wax moth colonized central parts of California at a much later date; there are at least 20 collection records from the San Francisco Bay area and Sacramento Valley in the past 40 years but none before that. The earliest vouchered record that I have seen is September, 1952, at Courtland, Sacramento Co. (CDFA); but probably *A. grisella* was widespread in central California by that time, as there are specimens from San Jose, Santa Clara Co. taken in 1955 by J. W. Tilden (SJS) and from Prunedale and Soledad, Monterey Co., in 1956 (CDFA). In the east bay, I took one specimen in 13 years sampling at Walnut Creek, Contra Costa Co. (June, 1964), and adults have been collected sporadically in Berkeley since 1968 (EME). A long series of *A. grisella* was reared by P. A. Rude from larvae in the honeycombs of an abandoned beehive in Kensington in 1978 (EME), but only four individuals, taken on four dates in 1983, 1987 and 1989, have been observed during the past 12 years sampling in Berkeley.

Discussion

Collection records indicate that at least 17 species of exotic Microlepidoptera and pyraloid moths have colonized the San Francisco Bay area during the past half century, including six during the most recent 10 years (Table 1). Five of these evidently were introduced independently from other populations in California, either directly from the Old World (*Batia lunaris, Esperia sulphurella*), or from the Pacific northwest or eastern U.S. (*Agonopteryx alstroemeriana, Athrips rancidella, Cnephasia longana*). The others colonized secondarily from southern California, by local introduction or gradual spread by adventive populations.

Among species that have reached the S. F. Bay area via southern California, several underwent a sequence of introduction-establishment then a long period of naturalization, followed by rapid range extension northward (e.g., Fig. 9) (or colonization via secondary introduction in the bay area). This pattern parallels that shown by other introduced insects, for example the passion vine-feeding butterfly, *Agraulis vanillae* (L.) (Powell 1961), the Old World earwig, *Euborellia annulipes* (Lucas) (Langston & Powell 1975) in California, and the European hesperiid, *Thymelicus lineola* (Ochsenheimer) in midwestern and northeastern U.S. and adjacent Canada (Powell 1983). Such delayed ecogeographical expansions by introduced insects may involve genetic adaptation to environmental situations to which the founder or even source populations were not adapted. The delay cannot always be documented because of incomplete records of adventive populations while they are at low levels, but gaps appear to have been as much as 17 years for *Symmoca signatella,* at least 40 years for *Platynota stultana,* 50 for *Uresiphita reversalis,* and 60 for *Crocidosema plebiana,* following widespread establishment in southern California.

By contrast, a few species have colonized in southern California and then apparently began expanding their range without appreciable delay during natu-

ralization. *Parapediasia teterrella* (Fig. 10) colonized the Sacramento Valley within 6–13 years after detection in the Los Angeles basin (but 21 more years passed before establishment in the east bay); *Pyramidobela angelarum* was established in Santa Clara and San Mateo counties eight years after its discovery in Los Angeles (Keifer 1942), and *Opogona omoscopa* reached the bay area within three years of first notice at Santa Barbara, although this may have been via independent introduction, and was widely established after two (San Diego Co.) to nine years (S. F. Bay area).

The data are too fragmentary to document the history of *Oinophila v-flavum* (Powell 1964b) and *Achroia grisella* in California. It would not be surprising to discover that such species have been established in the S. F. Bay area for a half century or more, as was the case for the urban tortricids, *Acleris variegana* (Schiffermüller) (Powell 1964a) in the bay area and *Clepsis unifasciana* (Hübner) in the Pacific northwest (Powell 1988).

Dowell & Gill (1989) compiled a list of 208 invertebrates that they classified as exotic and believed had been discovered in California between 1955 and 1988, based on several USDA and CDFA publications. They include 24 species of Lepidoptera, of which 16 are Microlepidoptera and Pyraloidea. The list is neither complete nor restricted to exotic species. Included are at least four species that likely are native insects:

Bucculatrix tridenticola Braun (erroneously given as Brown), which was originally described in 1963 from southern and eastern Oregon, eastern Washington, Colorado, Utah, and Nevada, occurs in association with *Artemisia tridentata* Nuttall in natural communities in Modoc County, California (several records in 1960s: Hall 1965; EME) and probably throughout the Great Basin. The probable origin inexplicably was given by Dowell and Gill as eastern U.S.

Periploca nigra Hodges was described originally from Sacramento in 1962 and was found to be widely established in the S. F. Bay area on ornamental junipers (Koehler & Tauber 1964). This may be an introduced species, but it is reported to range from New York to Louisiana "then west to Sacramento and San Diego, California" (Hodges 1978). The natural hostplants and geographical distribution in the west are unknown.

Choristoneura conflictana (Walker) is widespread across boreal America in association with *Populus tremuloides* Michaux and was reported from several sites in native aspen forests of the Warner Mountains, Cascades and Sierra Nevada, having been collected in California from 1922–1962 (Powell 1964a).

Eumysia mysiella (Dyar) is a widespread native insect of the Great Basin and southwest. It was described from Stockton, Utah, in 1905 and by the 1960s was recorded in Arizona, New Mexico, and Nevada (Heinrich 1956) (EME). Probably its natural range included California, east of the Sierra Nevada. The larval host is unrecorded, but the closely related *E. idahoensis* Mackie feeds on several species of *Atriplex* (Chenopodiaceae) (Mackie 1958).

Dowell and Gill's list omits several species that were first detected in California between 1955–1988, including *Opogona omoscopa,* discussed above; *Batia lunaris,* which was established on both sides of S. F. Bay by 1962 (Powell 1964c); *Esperia sulphurella,* an early spring, diurnal moth that was discovered at El Cerrito and Berkeley in 1966 and 1967 (Powell 1968) and has been recorded many times during the subsequent two decades (CAS, EME); and *Agonopteryx alstroemeriana,*

which was widely established in the bay area by 1984 (CAS, EME; Powell & Passoa in press) (Table 1).

Combining species validly listed by Dowell and Gill and those for which data are given here, yields a total of at least 27 species of exotic Microlepidoptera and Pyraloidea that have been discovered in California during the half century after 1940. The residency status of several of those included by Dowell and Gill is unknown; populations have been subject to eradication procedures, and/or we lack subsequent collections to confirm colonization and spread (e.g., *Homadaula anisocentra* (Meyrick) and *Endothenia albolineana* (Kearfott)).

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